Analysis and Definition Report for NPD 2820Metrics

Attachments:
1. Measurements Requirements
2. Checklist for assessment of Program/Project (Acquirer)
3. Checklist for assessment of software provider
4. Sample Metrics

1. INTRODUCTION

This report provides the initial results of a comparison of existing capabilities software tool to NASA needs and NPD requirements. It includes an initial recommended metrics set for a defined audience with some options for collection responsibility. The following sections address the results of the comparison, the three main areas of measurement requirements (evidence of conformance, agency trends, and results), and some possible additions. Attachment 1 contains an extract of Section 7 from NPD 2820 for easy reference. Attachments 3 and 4 provide some recommended checklists that would support the evaluation of NPD requirement compliance. Attachment 4 provides an initial set of metrics, which will evolve as the research and analysis matures and the updates addressed in future reports.

2.0 COMPARISON WITH EXISTING CAPABILITIES

There appears to be little commonality between the metric measures that are required by NPD 2820 and the capabilities of some existing tools. One of the existing tools reviewed is a tool called Software Control Panel. The measurement requirements of NPD 2820 require metrics that address: evidence of conformance to NPD requirements, agency trends in cost, schedule, and degree software satisfies requirements, and results in ISO/CMM assessments, surveys, improvements due to CMM and improvements from shared experiences. The Software Control Panel supports the reporting of metrics in the areas of: earned value, cost performance index, to-complete performance index, quality gate task status, quality gate task completion, configuration management churn per month, requirements change per month, voluntary turnover per month, overtime per month, risk exposure, risk reserve, and defects by activity. From this quick comparison it appears that the tools covers a much wider set of metrics (and more geared to project reporting as opposed to the higher level metrics being required by the NPD) than that required by the NPD. With such a wide discrepancy between the existing tool and the NPD requirements, no supportive recommendation can be made as to the use of the tool. However, the tool should be kept in the analysis as the recommendations for the NPD 2820 metric set matures in case future results bring the metrics needed to support NPD 2820 more in line with the capabilities of the tool.

3.0   METRICS

This section will discuss each metric area (measurement requirement; see attachment 1 for an extract of the measurements requirements from the NPD) individually.

3.1 EVIDENCE OF CONFORMANCE

Assess program/project conformance to the NPD 2820 through the use of checklists. Attachments 2 and 3 are proposed as possible checklists for use in these assessments. The assessments would be performed as follows:

  a. Assessment of acquirer (program/project) prior to provider (e.g., developer) selection.
  b. Assessment of acquirer and provider prior to completion of requirements specification and before design and coding begin.
  c. Assessment of acquirer and provider prior to testing
  d. Assessment of acquirer and provider at delivery

This type of information is to be reported to the appropriate Program Management Council (PMC) per paragraph 7.a(1). As such the responsibility for gathering the data could be assigned to the program/project office or to some other center/enterprise designated organization. The results of these checklists could be included in the review report that the PMC is to record and forward a copy to the IV&V Facility, per paragraph 5.f. The IV&V Facility could then produce a metric on conformance as shown in attachment 4 (see last sample metric).

3.2 AGENCY TRENDS

The responsibility for developing agency trend metrics is the responsibility of the IV&V Facility, per paragraph 5.d. However, in order to develop those trends the IV&V Facility will need source or metric data from individual programs/projects. There are three possible approaches to collecting cost and schedule data. A center/enterprise designated representative could obtain raw cost and schedule data for the IV&V Facility, metrics on cost and schedule could be generated by the program/project reported to the PMC and passed to the IV&V Facility, or the IV&V Facility could use earned value data (many programs/projects are required to develop earned value data per NPG 7120.5A) generated by the program/projects (again this could be part of the information presented to the governing PMC). Attachment 4 shows some candidate cost and schedule metrics that could be generated by the IV&V Facility.

The metrics for requirements will be more difficult. The classic means for assessing the degree to which software satisfies requirements is to conduct a Functional Configuration Audit (FCA). The FCA assesses the test results, reviews the test verification trace matrix (the trace of test cases to requirements), and determine the extent to which each requirement has been verified. The results typically range from pass (few severity ≤ 3 problem reports open), partial (severity 3 problems open preventing full capability), fail

(severity 1 and/or 2 problems open), to not tested. Some consider the use of FCAs as impracticable on small or R&D software acquisition efforts. FCA data could be used if FCAs are scheduled to be performed. Otherwise, criterion for success will need to be identified and as well as the methods to be used to verify that the criterion is successfully met (that criterion and verification process should be documented in program/project planning). From this metrics as shown in attachment 4 (requirement verification) could be developed.

3.3 RESULTS

The results of ISO and CMM assessments and audits can be collected in one of two ways. The first is through the use of the checklists. This is where an assessment of available documentation is made to determine if the provider is independently ISO/CMM certified or self assessed (note: if provider is self assessed as ISO/CMM compliant then the checklist list records this in the category of other as far as evidence is concerned). Another assessment is made to determine the certification/compliance level of the provider. The results of such an audit/assessment would include the identification of the claimed certification or compliance and the results of the audit/assessment in terms of the number of major and minor findings. The IV&V Facility could use the data to generate metrics as suggested in attachment 4.

Results of other surveys are not clearly defined in the NPD. Assume that this would entail any surveys/audits/assessments performed to verify acquirer/provider capabilities/processes not directly covered under ISO/CMM (e.g., prototyping or R&D software development effort performed by a provider, who is not ISO/CMM compliant). The IV&V Facility could generate metrics as suggested in attachment 4.

The IV&V Facility could also generate metrics on improvements resulting from CMM. Since the early portion of the measurement requirements request information only on cost, schedule and requirement verification, the measure of improvement will be limited to that. The source of this data could be obtained from the checklist, cost/schedule and requirement verification. Crucial to this is the assessment taken at software delivery (Note: in a multiple release/delivery program assessments and cost/schedule/requirement evaluations could be made at each release/delivery). The IV&V Facility could produce the metrics as suggested in attachment 4.

The IV&V Facility could generate metrics on improvements resulting from use of shared experience. This metric will be difficult as there was no previous requirement to capture shared experience data. An approach is discussed in section 3.4.6.

3.4 RECOMMENDED ADDITIONS

The following metrics are not specifically addressed in the NPD 2820, however they are considered to be worthy for consideration for addition to the metric set outlined above.

3.4.1 Quality

There is no specific measurement requirement for quality of software in the NPD. One of the best methods for gauging the quality of software is by the count and severity of open problem reports. A metrics from the program/project database on the count of problems for total (open/closed) and for the total for each level of severity could be developed. The IV&V Facility could then include this aspect of quality into the metrics addressed in section 2.3 in terms of number of open problem reports at delivery.

3.4.2 Program/Project Profile

The program/project checklists obtain little information about the acquisition other than that related to ISO/CMM and planning documentation. Additional information bout the acquisition effort should be obtained to allow IV&V to perform a more thorough analysis of software across NASA. Recommend that the following items be included in the provider checklist:

- Estimated/actual size of developed code, in terms of Source Lines of Code (SLOC)
- Language(s) being used
- Development approach (e.g., structured, OO)
- Purpose of software (e.g., prototype, simulation, operational)
- Number of COTS packages to be integrated into the system
- Estimated/actual size (SLOC) of GOTS being reused

3.4.3 COTS

The NPD addresses that it is applicable to COTS, however there are no specific measurement requirements associated with COTS. The following should be considered:

- COTS vender rating in regards to certification or conformance to ISO/CMM (this would be added to the provider checklist)
- Problem report metric for those problem reports associated with any COTS product (This metric would be used just like that described in 2.4.1 above)
- Degree to which COTS satisfies allocated requirements (this would be done as described in the second paragraph of 2.2 above; the difficulty is getting data that traces requirements to COTS)
- Cost and schedule associated with COTS (this would be done as described in the first paragraph of 2.2)

3.4.4 Improvements ISO

The NPD defines improvement measures for CMM but not for ISO, while very similar they are not completely identical. As a result, it is worthwhile to measure improvements associated with ISO as well. The metric would be collected and analyzed as described in the third paragraph of 2.3, except the focus of the metric would be on ISO providers.

3.4.5 Reuse

The NPD mentions that it is its policy to facilitate reuse of NASA funded software, GOTS (Government Off The Shelf). There are no measurement requirements for reuse. A metric could be developed by the IV&V Facility using the GOTS SLOC information,

obtained from recommendation 2.4.2 above, to show the percentage of GOTS reuse over time.

3.4.6   Shared Experience

In order to assess improvements due to the implementation of shared experiences, a definition and tracking methodology is needed for "shared experiences". "Shared experiences" should be defined as some practice/approach not codified in any commercial standard, process or best practice that has been tried with success on some other program/project(s) (e.g., cleanroom). A shared experiences item should be added to the checklist for the acquirer and provider, and the information collected by the SMA representative. The IV&V Facility would then develop a metric to identify improvements associated with this process in terms of cost/schedule/requirements verified (per third paragraph of 2.3) and quality (per 2.4.1).

3.4.7   Risk Management/Mitigation

Risk management is identified as an important part of the NPD. Metrics can be developed to assess implementation of risk programs and obtain information on successful mitigation strategies. One approach is to add to the acquirer and provider checklists an item on "has a risk management program been implemented and working" and also on the checklist "what mitigation strategies are considered most successful" (this item would be filled in mostly toward the end of the effort). The IV&V Facility would use this information to develop a metric that shows the top four/five successful strategies from those programs/projects that implemented a working risk management program. Another might be to have the SMA representative develop from the program/project risk management database a profile of program/project risk counts over time. See attachment 5 for sample metrics.

3.5 RELATIONSHIP TO 7120.5A

NPG 7120.5A discusses the use of earned value management. The effective use of this as a cost/schedule metric that can be used by the IV&V Facility needs further investigation. The concern here is whether the earned value metrics can be used solely or whether the cost and schedule data used by IV&V Facility should include estimated/actual software cost profile over time and schedule information based on original/actual schedule information.

NPG 7120.5A identified the technical baseline and change control as important parameters. A metric measure of this can support the requirements of both directives, by using a metric focused on requirements (representative of the technical baseline). An approach would be to have a metric developed, from program/project databases, that shows the total number of requirements over time and the number of requirements modified during a particular time interval (by showing the number of modified requirements during a time interval and not cumulative, should give an indication of whether fine tuning or major modifications is being done). See attachment 4 for sample metric.

4.0 CONCLUSION

This report has attempted to define an initial set of candidate metrics that could be used in support of NPD 2820. This set of metrics will be refined and updated in later reports as the concepts for supporting the requirements of this NPD mature.

ATTACHMENT 1 - Measurements Requirements (extract from NPD 2820, Section 7)

7. Measurements

a. The following shall be evaluated for compliance with this directive:

(1) Evidence of project conformance to this policy as reported to the governing PMC.

(2) Agency trends on the following:

(a) Software cost and schedule baseline deviations; and

(b) Degree to which delivered software satisfies its requirements, including safety, quality, and reliability measures.

(3) Results of the following:

(a) Assessments and audits of conformance to ISO 9001 and the CMM in NASA software creation and acquisition organizations;

(b) Other surveys relating to the implementation of this directive;

(c) Improvements in software acquisition and creation on software projects, resulting from the use of CMM;

(d) Improvements in management of software creation and acquisition, resulting from c and shared experiences.

b. Specific responsibilities for collecting, analyzing, and reporting metrics are contained in NPG 2820.

ATTACHMENT 2 - Checklist for assessment of Program/Project (Acquirer)

Program/Project assessment Checklist:
1. Program/Project Software Acquisition and Life-cycle Management Plan Checklist
(Note: could be a separate plan or incorporated into overall Program/Project Plan)
- Was the plan developed prior to provider selection?
- Does the plan address design trade-off management?
- Does the plan address risk management?
- Does the plan address requirements management?
- Does the plan address software project planning?
- Does the plan address project tracking and oversight?
- Does the plan address software product engineering?
- Does the plan address subcontract management?
- Does the plan address configuration management?
- Does the plan address quality assurance?
- Does the plan address peer review?
- List any other items addressed not listed above?
(Note: These topics can be a part of a plan or documented as a separate plan.)

2. Has the program/project developed and maintained a total estimated software life-cycle cost?

3. Has the program/project performed trade-off studies that address the use of COTS and GOTS versus developed software to satisfy requirements (where appropriate)?

4. Has the program/project tailored common industry standards, processes and best practices to this development or acquisition?
- If so, list the standards and practices, and indicate whether it was tailored or not.

5. Has the program/project used other than commercial standards, processes, or best practices for this development/acquisition?
- If so, list the standards and practices, and indicate whether it was tailored or not.

**ATTACHMENT 3** - Checklist for assessment of software provider

Provider assessment Checklist:
1. Demonstration that provider has capability and experience to deliver quality software on time and within budget, by one of the following methods:
   a. Is the provider independently certified for ISO 9001 compliance as described in ISO 9000-3?
   b. Is the provider independently assessed as having a software Capability Maturity Model (CMM) rating of 3 or above?
      - If yes, identify the rating.
   c. Other evidence?
      - If other, describe. (Note: self assessments of ISO and CMM compliance are considered as under this category of other.)

2. Provider Software Management Plan Checklist
   - Was the plan developed before the completion of the software requirements specification and software design and coding has taken place?
   - Does the plan address design trade-off management?
   - Does the plan address risk management?
   - Does the plan address requirements management?
   - Does the plan address software project planning?
   - Does the plan address project tracking and oversight?
   - Does the plan address software product engineering?
   - Does the plan address subcontract management?
   - Does the plan address configuration management?
   - Does the plan address quality assurance?
   - Does the plan address peer review?
   - List any other items addressed not listed above?

(Note: These topics can be a part of a plan or documented as a separate plan.)

3. Has the provider performed trade-off studies that address the use of COTS and GOTS versus developed software to satisfy requirements (where appropriate)?

4. Has the provider tailored common industry standards, processes and best practices to this development or acquisition?
   - If so, list the standards and practices, and indicate whether it was tailored or not.

5. Has the provider used other than commercial standards, processes, or best practices for this development/acquisition (specifically, has the provider used standards,, processes, or best practices unique to the provider)?
   - If so, list the standards and practices, and indicate whether it was tailored or not.
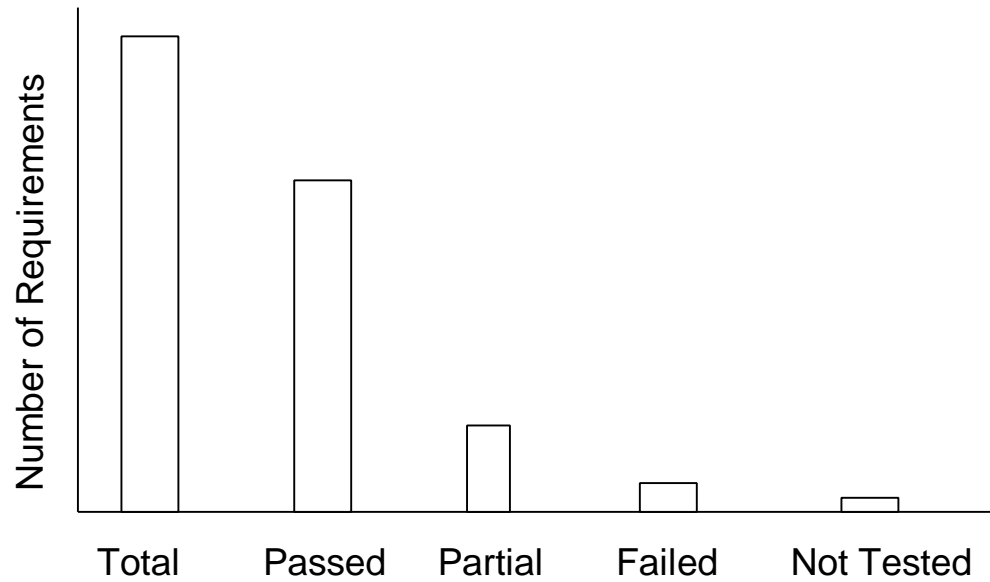
ATTACHMENT 4 - Sample Metrics

The two samples on this page are outlined in section 2.2 and relate to measurement
requirements found in paragraph 2.a of attachment 2.
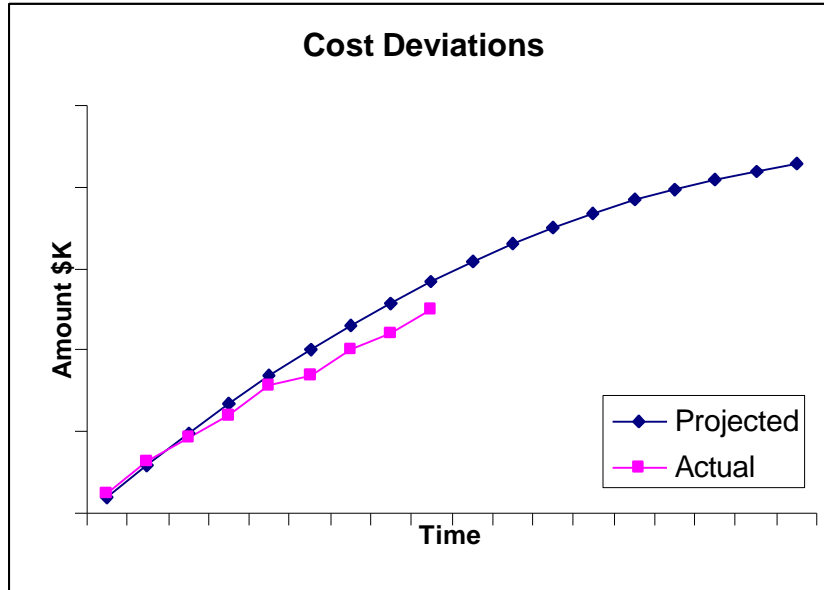
Cost Deviations
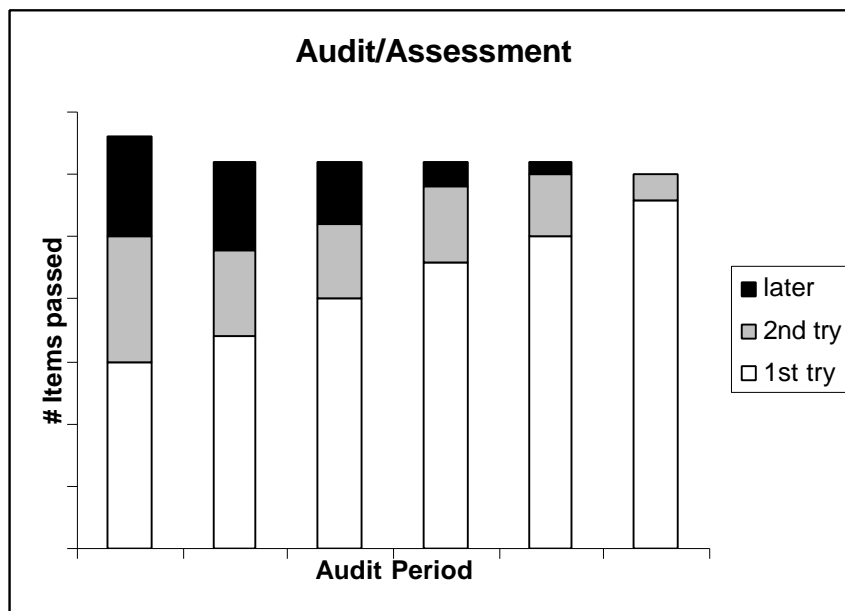
2a - Sample of cost deviations

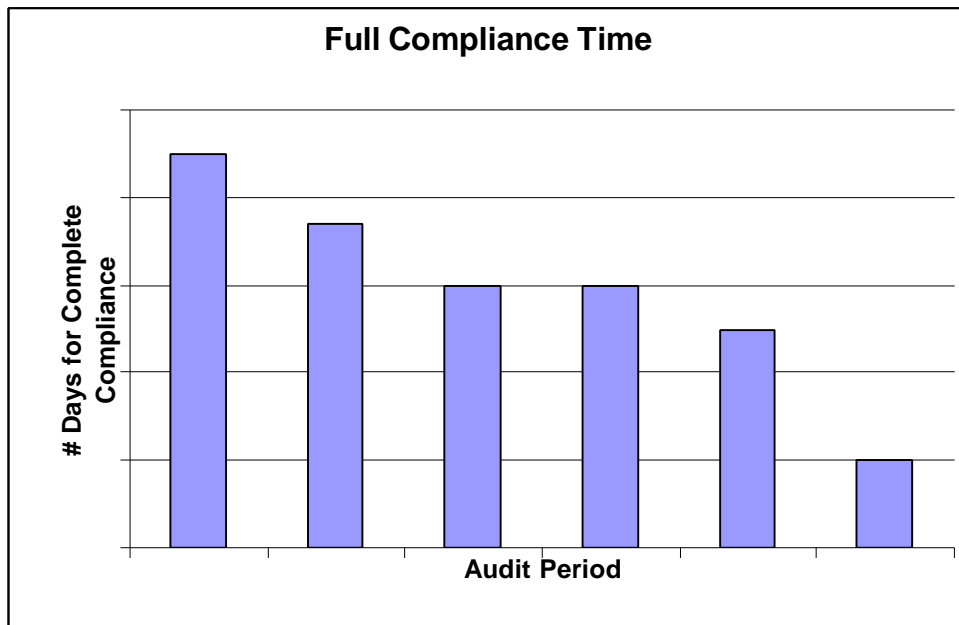**Deviation from Planned**
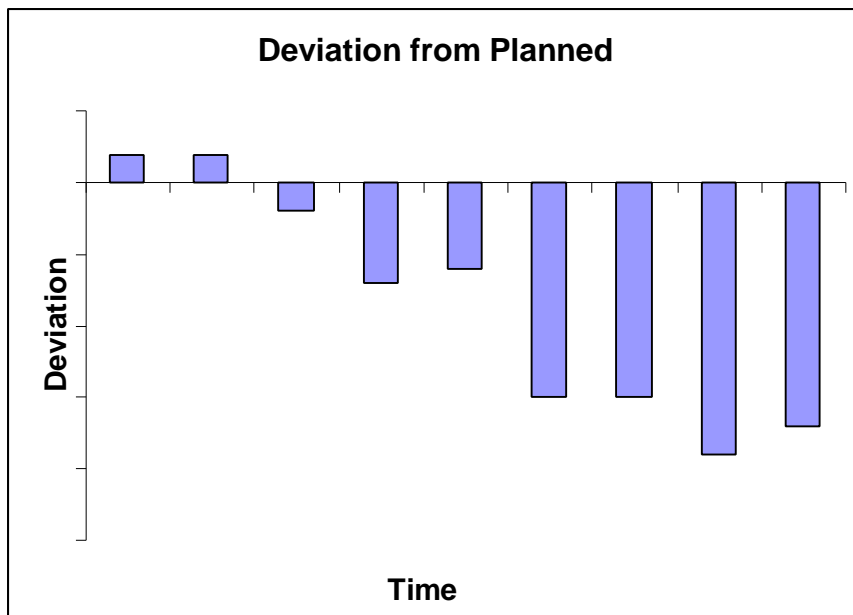
2 a - Sample of schedule deviation
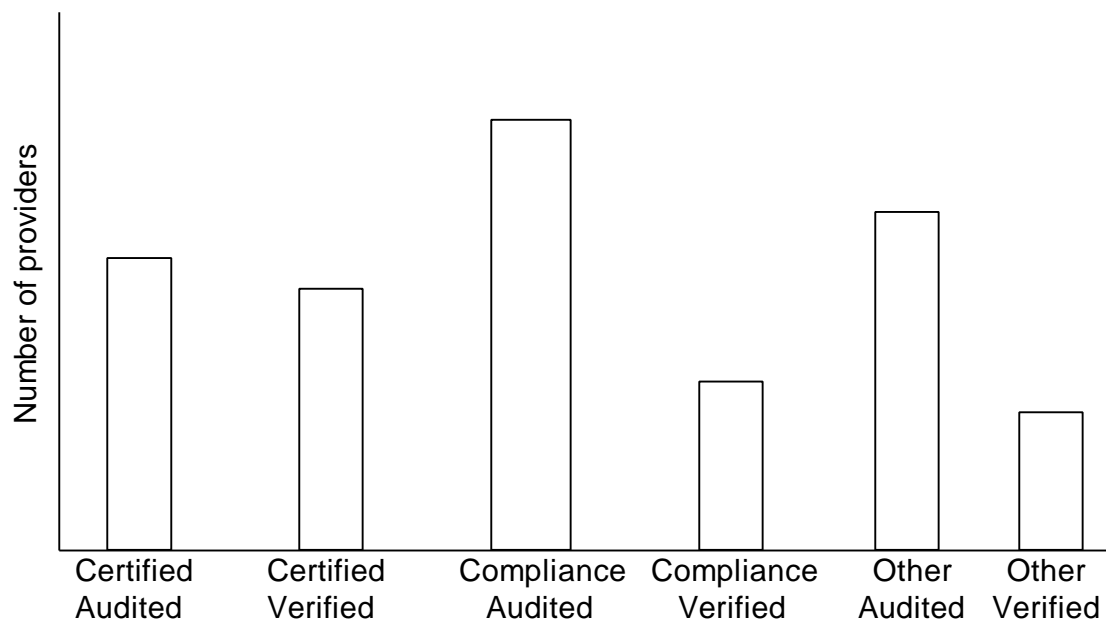
2b - Sample of Software Requirement Verification

The above sample is discussed in section 2.2 and relates to measurement requirement 2.b of attachment 2. The next three samples provide different metrics for measuring compliance as addressed in section 2.3 and relate to measurement requirements 3 a and b in attachment 2.
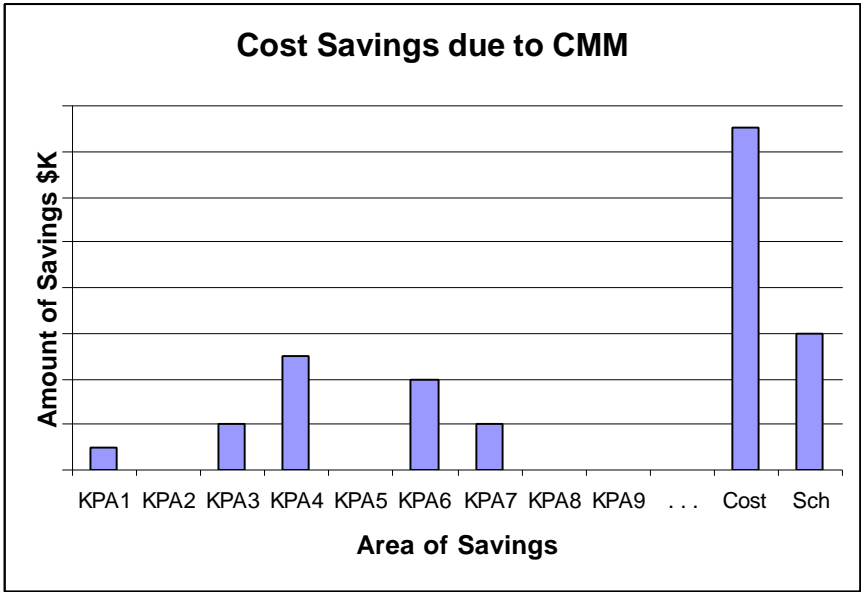

3a - Audits & Assessments

Full Compliance Time

Days for Complete Compliance

Audit Period

3a - Audit compliance time

Number of providers

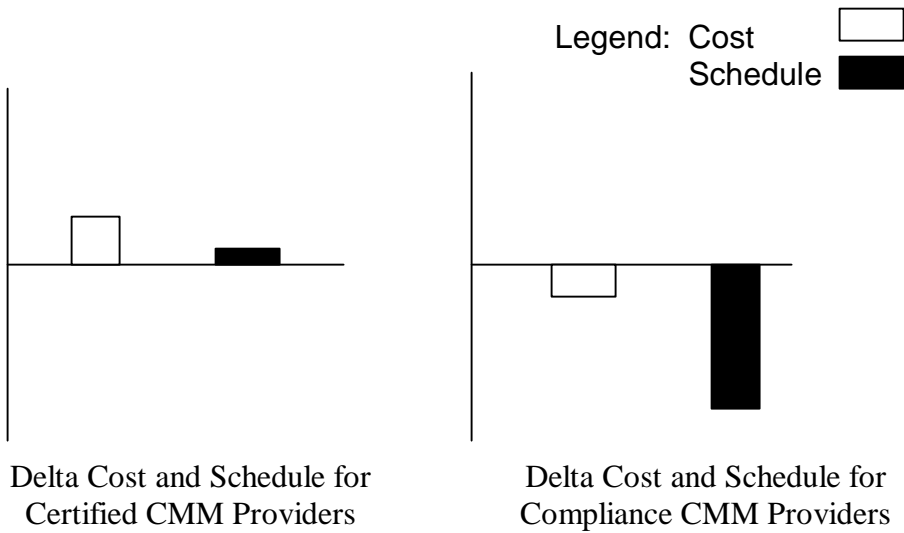Certified Audited | Certified Verified | Compliance Audited | Compliance Verified | Other Audited | Other Verified

3 a and b - Metric on Audits and Assessments

The next two samples are addressed in section 2.3 and relate to measurement requirement 3.c.

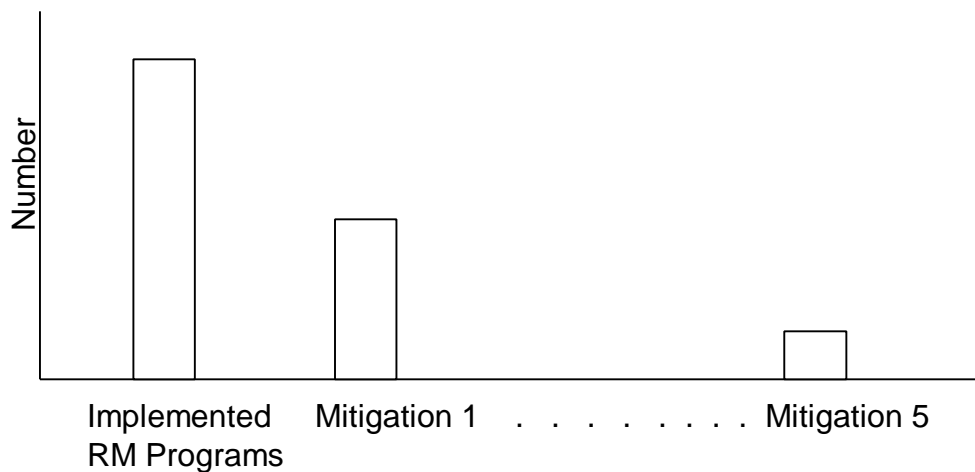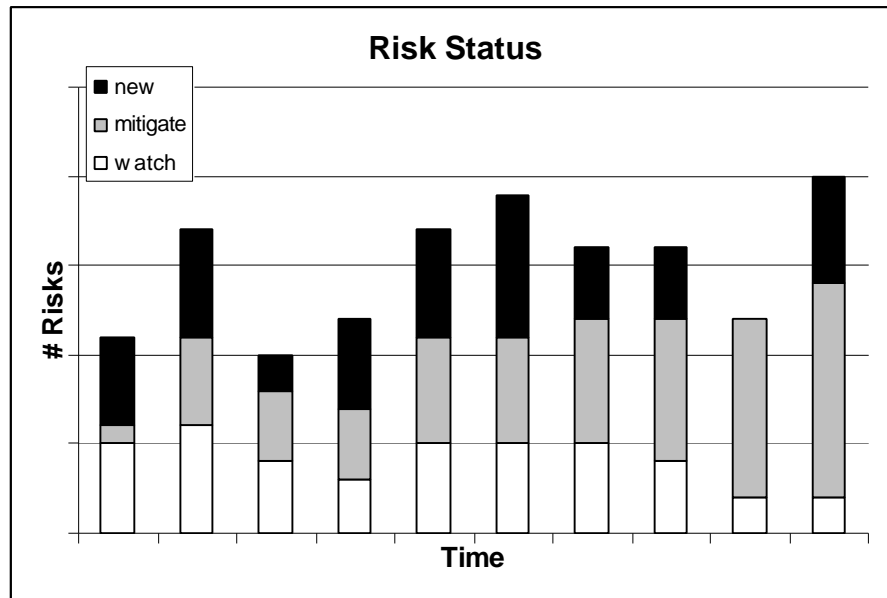**Cost Savings due to CMM**

CMM improvements by KPA - associated $ value

Delta Cost and Schedule for
Certified CMM Providers

Delta Cost and Schedule for
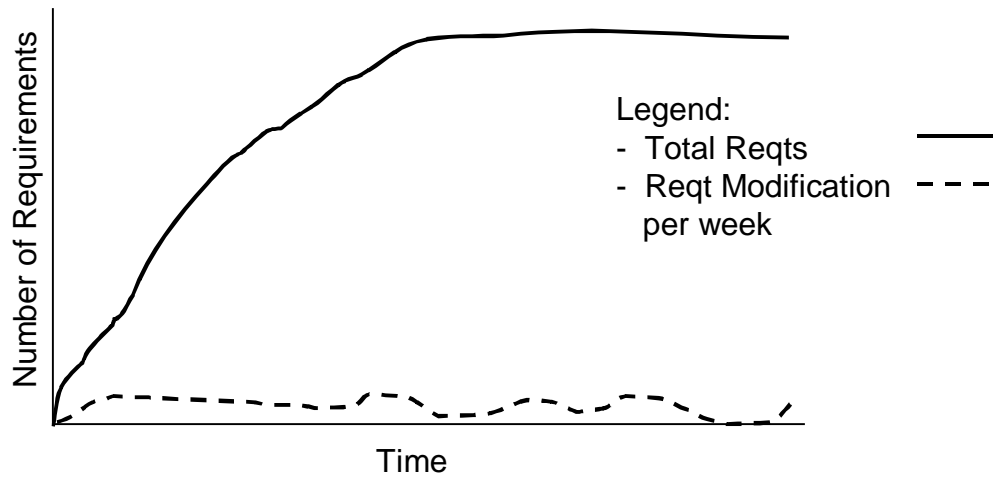Compliance CMM Providers

Legend: Cost
Schedule

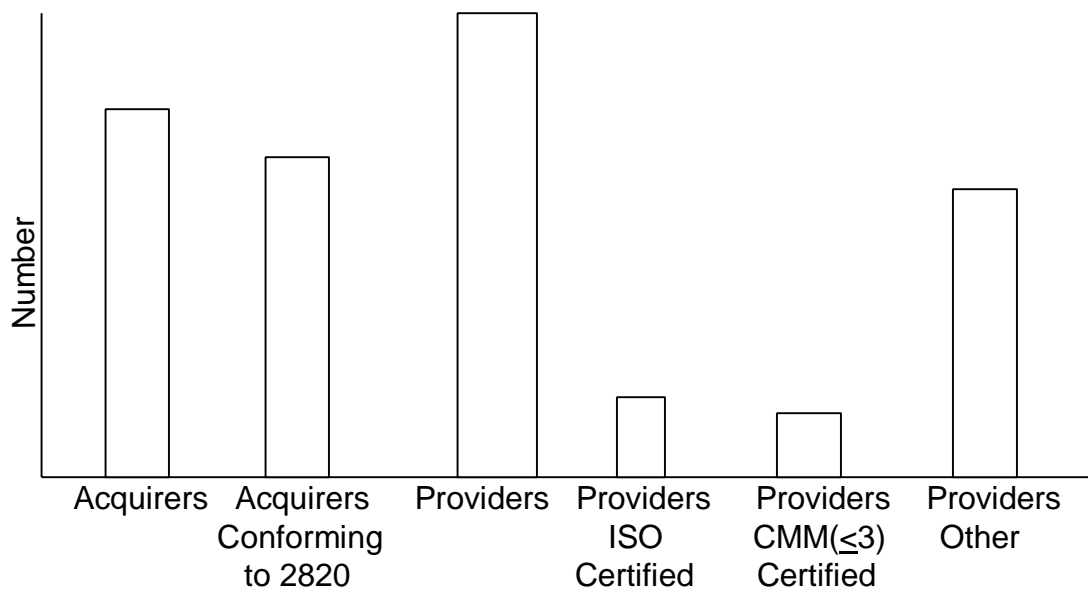3 c - Metric on Improvements Resulting from CMM

The following two metrics samples are addressed in section 2.4.7.

Metric showing effective mitigation strategies from programs having implemented a Risk Management Program

Metric showing requirement volatility over time. Addressed in section 2.5

This sample metric is addressed in section 2.1 and relates to measurement requirement 1 in attachment 2